IOT based Smart Crop Suitability System

Design Document

Project ID: 19-015

C.P. Wickramasinghe
(H.P.H.S. Hemapriya, P.L.N. Lakshitha, P.G.N.S. Ranasinghe)

B.Sc. (Hons) Degree in Software Engineering,
B.Sc. (Hons) Degree in Computer Systems and Network Engineering

13th May 2019

IOT based Smart Crop Suitability System

Project ID: 19-015

C.P. Wickramasinghe
(H.P.H.S. Hemapriya, P.L.N. Lakshitha, P.G.N.S. Ranasinghe)

B.Sc. (Hons) Degree in Software Engineering,
B.Sc. (Hons) Degree in Computer Systems and Network Engineering

Supervisor: Dr. Anuradha Jayakody

13th May 2019

DECLARATION

We hereby declare that this is our own work and this Design Document Specification does not incorporate without acknowledgement any material previously submitted for a Degree or Diploma in any other University or institute of higher learning and to the best of our knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text.

Name: C.P. Wickramasinghe (IT16034600) Signature: ……

Name: P.L.N. Lakshitha (IT16021594) Signature: ……

Name: H.P.H.S. Hemapriya (IT16102460) Signature: ……

Name: P.G.N.S. Ranasinghe (IT16119772) Signature: ……

Table of Contents

List of figures

List of tables

1. INTRODUCTION

1.1. Purpose

The predominant purpose of this Requirements Design Document (RDD) is to provide a detailed description of the functionalities of the system 'Smart Crop Suitability System '. Therefore, this document will cover each of the system's intended features, as well as offer a preliminary glimpse of constraints and their effects on the system. The document will also cover hardware, software, and various other technical dependencies.

The main motive of this document is to acknowledge the implementation of sensor subsystem of the system. As one of the main parts of the system, a detailed description is presented about the components which assist used in the system. Special features to be added and conclusion made at the end of the literature survey which led to the necessity of the features are discussed. Furthermore, the required duration of the implementation within the time frame and the deliverables to be distributed at the end of the implementation are reported in detail

1.2. Scope

This document will cover how the proposed system's main objective Develop the sensor sub system using EC and temperature sensors and establish the entire system for the data communication with the Raspberry Pi. Using the sensor subsystem sensor readings (pH, EC, moisture, temperature) from soil use to develop the algorithm using machine learning. Algorithm can generate soil nutrients from sensor readings and suggest the most suitable crop considering the main soil nutrients, such as N, P, K, and environmental factors with ground type (rough, salty, sand) can predict the most relevant crop for the soil. Establish the entire system to data communication with cloud to remote access to all sensor data (pH, EC, moisture, temperature) in soil. Check entire system for the errors for the final product. Only 2 sensors were focused in this document.

In addition, the methods used in system's accuracy and efficiency are presented to highlight their importance which is to overcome the disturbance or malfunctions caused when using the system. The hardware components that are expected to be used in the

system, the innovative hardware equipment, the user interfaces and the connection between the hardware and UIs are depicted in detail.

1.3. Definitions, Acronyms, and Abbreviations

UI	User Interface
Rasberry Pie 3 B+	Rasberry Pie is an open-source electronics platform based on easy to-use hardware and software.
EC sensor	Measure Electrical conduction in soil.
Temp sensor	Measures temperature in soil/ Environment

Table 1: Definitions, Acronyms, and Abbreviations

1.4. Overview

The first chapter focused on the introduction to this application. This application is mainly targeted an easy way to realize the most suitable crop that can be grown in a particular land with a fertilizer plan in order to have a successful cultivation and avoid soil degradation due to excess fertilizer usage.

In the second chapter of the document provides overall description of the functionality and interaction with the other component. This section also discusses the interfaces, constraints and operations to provide better understanding of the product. Further it explains characteristics of users, constraints of the system, comparison with an existing product, assumptions, and dependencies, and apportioning of requirements.

From the third section of the document, user specifications, risks of the hardware components, architectural design details are described and maintainability, security and the references are provided at the bottom section of the document.

Our main target audience would be farmers and new cultivators and both second and third chapters are explaining the same product in two different languages since this document uses a different audience.

2. OVERALL DESCRIPTIONS

Main goal of this system is to select suitable crop to cultivate on desired lands. In order to get suitable crop user need to log in to the system and after the login user need to select ground type from drop down menu. After that user need to enter ground area by perch.

Then app suggest how many readings should get for best results. App will not continue if the suggested reading count does not fulfilled. After selecting, device should insert in to the soil and wait less than a minute to get sensor readings. Sensor sub system get pH, EC (electrical Conduction), Temperature and humidity from relevant sensors. After getting all sensor readings calculate with algorithms in Raspberry pie and send calculated data to cloud server. Generating the future fertilizer plan after successfully predicting the most suitable crop for a particular ground is a key point in this application. The gathered soil data by sensors will be stored in the cloud for the future use. The stored data will then perform the process of generating the future plan for the selected crop, with an in-built data set by using machine learning techniques.

The future fertilizer plan includes the relevant time periods with the amount of fertilizers that should apply for the crop to achieve a successful cultivation. User will be notified according to each time period in the generated fertilizer plan. By applying those methods in the accurate time will guide user to have a successful cultivation.

The system will also give user the ability to search accurate solutions for any defects of the crop in the time period of growth.

Recommending fertilizer for application suggested crops is a major part of this application. In order to suggest the fertilizer, mobile application retrieve stored sensor data (pH, EC, Humidity, Temperature) in cloud server and generate the average nutrient levels existing in the particular land.

When farmer select an application suggested crop, using in built data set with relevant to crops, application will identify the approximate amount of nutrient levels that should be in land in order to have the successful harvest from the relevant cultivation. Then application generate the deficiency amount of nutrient levels in existing soil to have better harvest by comparing identified data with existing nutrient levels. By using a data mining technique in machine learning algorithms, application will compare deficiency nutrition levels with in - build data set with relevant to fertilizer, and will recommend necessary amount of fertilizers a farmer should use in order to have the best harvest.

If by any chance farmer wanted to grow different crop other than crops included in suggested list, he can search for that crop details. If the requested crop can be grown in the land only by adjusting the existing nutrient levels in soil, application suggest the amount of fertilizer that should be used in order to plant that crop. So the farmer can make the land suitable for that crop to have a better harvest.

Several important processes are discussed in this section such as how the operations are going to be executed and control, how these operations communicate with users, system requirements, and relevant interfaces and how each component activities are communicated with other components and the importance for the successful final product.

As well, all the definitions are provided at the top of the document and it will be more helpful to get a clear idea of the whole process and the future changes of the system. As the design document provides hardware component details, it will be more effective with developers as well.

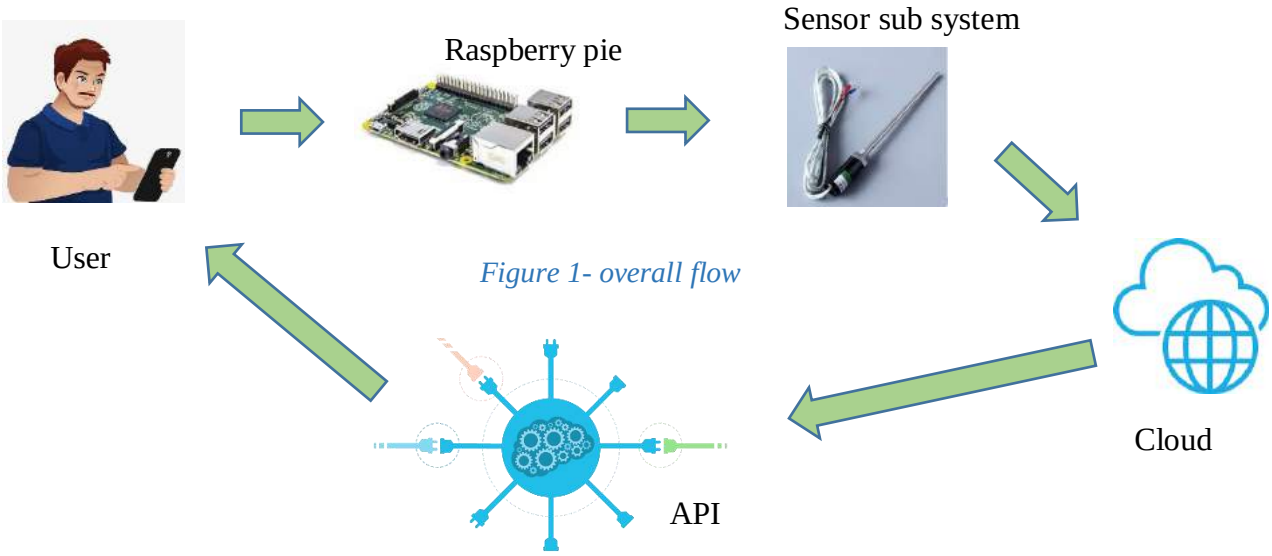

Figure 1- overall flow

2.1. Product Perspective

Various systems that cater similar requirements were discovered during the literature survey. After the analysis of the systems discovered, each of them contained few defects and minor weaknesses in the technologies that were used.. Reported below are few of the existing systems that cater insignificant requirements of the proposed system and a brief description of the systems discovered. There are many types of researches based on predicting the crop growth by using different tools and techniques. According to the

researchers Joon-Goo Lee and Haedong Lee, they have used image processing techniques for develop same kind of an app.[2]Also most of the products use either expensive sensors or chemicals for the soil tests. But in this proposed system will develop a tool with attaching sensors which will test the main factors like pH, electrical conductivity (EC) of the soil and temperature, humidity of the air.

The future fertilizer plan will be generated according to the data gathered through sensors with processing in-built data set in the mobile application. Because the in-built data set will store not in the cloud storage, but within the mobile application, the user does not need to download the data set to the mobile phone each and every time when he/she uses the application.

Various systems that cater similar requirements were discovered during the literature survey. After the analysis of the systems discovered, each of them contained few defects and minor weaknesses in the technologies that were used. [3] Since the proposed system serves the accessibility for physically disabled people who would be dumb, this target audience is underprivileged in using the systems operated via speech recognition.

Reported below are few of the existing systems that cater insignificant requirements of the proposed system and a brief description of the systems discovered.

2.1.1. System Interfaces

Smart Crop Suitability System is a cross platform mobile application which is compatible with multiple mobile operating systems. Visual studio will be used as the development environment for this application. As well, Raspberry pi platform is going to be used to develop the hardware component.

2.1.2. User Interfaces

- Login Page

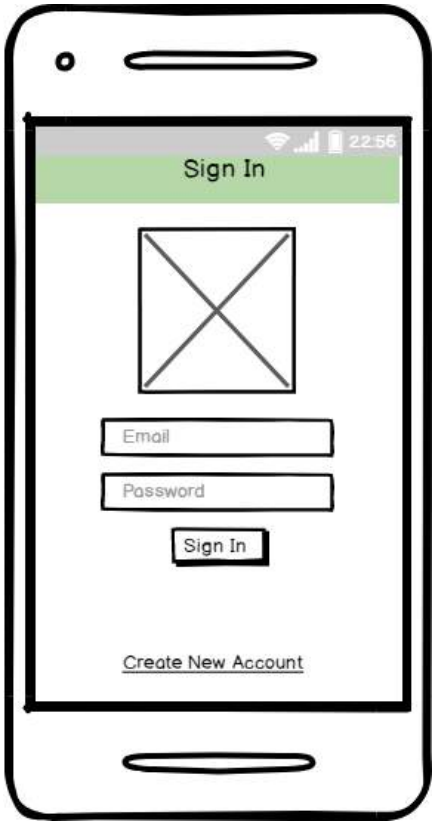

Figure 1: User interface - Sign in

- Create an Account

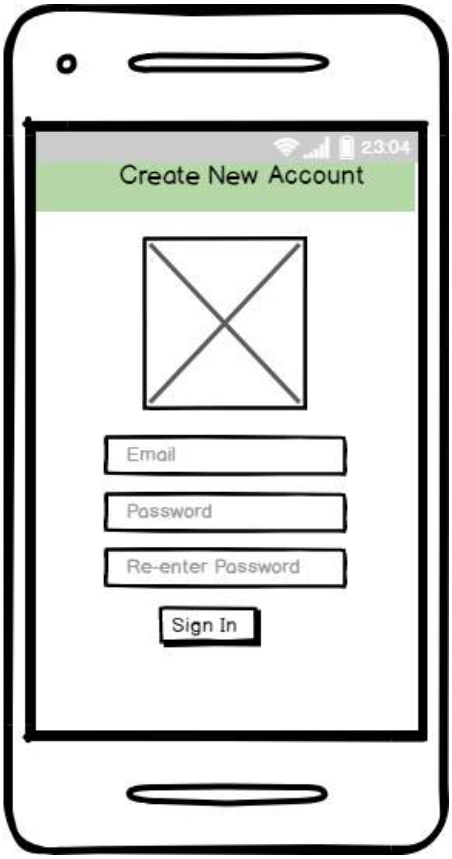

Figure 2:Create an account

- Generate required minimum reading count

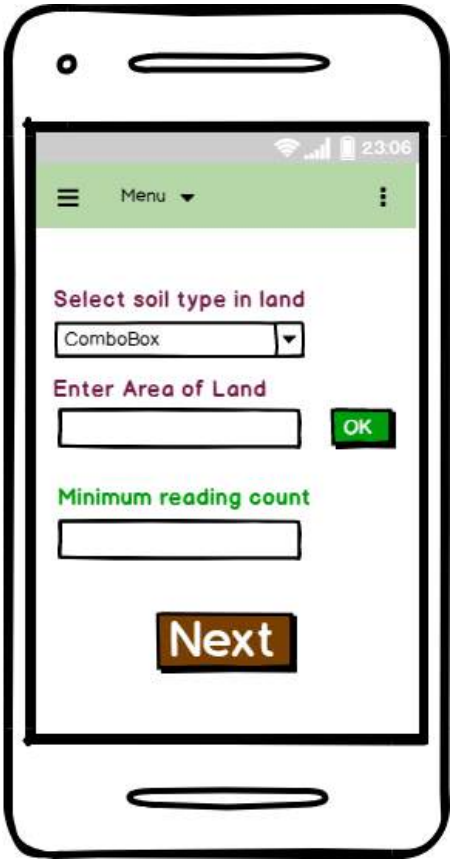

Figure 3:generate reading count

- Suggest most suitable crop list

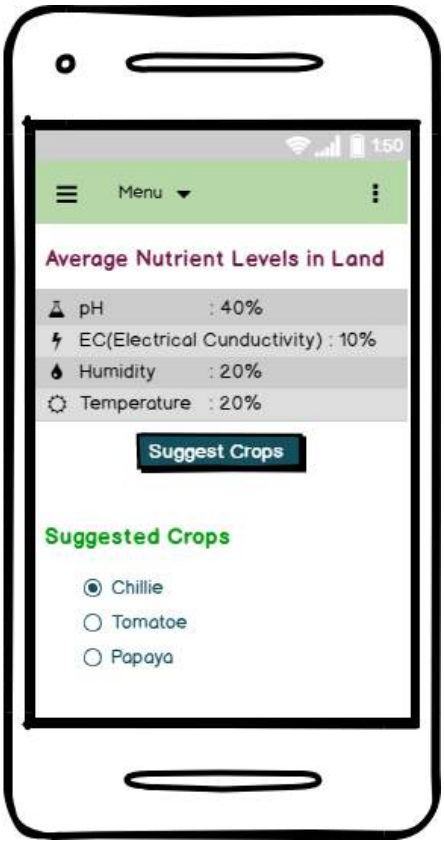

Figure 4:suggest most suitable crop list

- Recommend fertilizers to obtain successful harvest

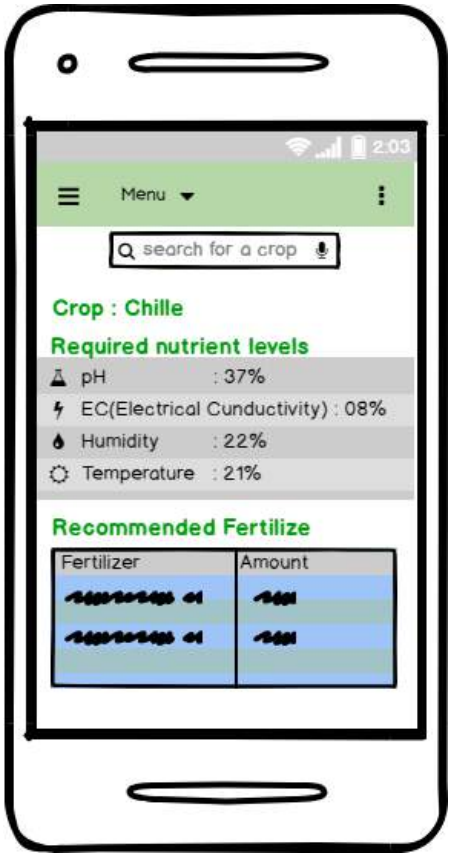

Figure 5:recommend fertilizers

- Generate future fertilizer plan

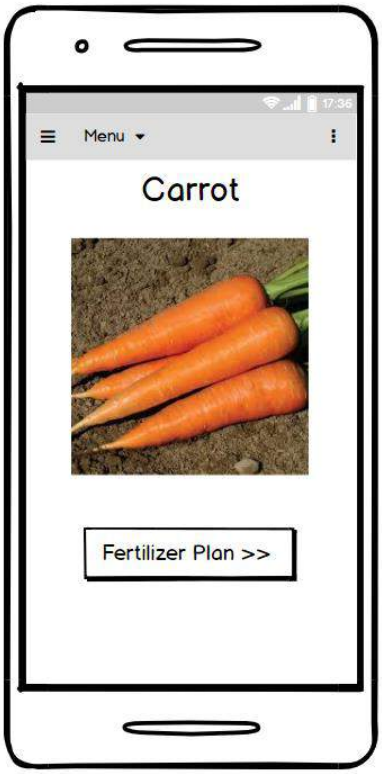

Figure 6: User interface - navigate to view fertilizer plan

Figure 7: User interface - View fertilizer plan

Figure 8: User interface - Search solutions for the defects in crop

2.1.3. Hardware Interfaces

As there are several main and sub-objectives in this proposed product, some hardware components are going to be used to satisfy those as follows,

- pH sensor
- EC sensor
- Temperature sensor
- Humidity sensor
- Raspberry pie
- Smart phone

2.1.4. Software Interfaces

Visual studio 2016	Developing cross platform mobile application
phpMyAdmin	MYSQL database management
Cloud	To store the sensor data and in-built data set
RaspberryOS terminal	Program Raspberry Pie

Table 2: Software interfaces

2.1.5. Communication Interfaces

We use raspberry pi board as our principle sensor centre point to get and upload the sensor readings to cloud server. In order to store sensor reading in cloud server Raspberry Pie board and the cloud server will be connected using in built Wi-Fi module in raspberry pi board. Smartphone should be connected to the internet using mobile data or WIFI to retrieve data from cloud.

2.1.6. Memory Constraints

The Mobile application is required,

- Android version should be 5.0 or higher
- 1 GB RAM
- 100 MB Memory space

2.1.7. Operations

Final outcome of this proposed solution is a product and a cross platform mobile application, the mobile application will be interacted with the process for achieving

particular goals. Therefore, to use this proposed product, the user should install the "smart crop" mobile application.

1. The user should sign in and if he doesn't have an account, then he should create an account.
2. When the mobile application is going to be used by the user, first he should enter the soil type and area of the particular land where he going to start the cultivation.
3. User should get sensor readings from with the help of sensor embedded tool, until the application suggested required reading count is fulfilled.
4. When taking readings from land user should use zig-zag soil testing method in order to take soil samples from the different places in the land.
5. To take the most accurate readings from sensor embedded tool, user must take reading while the soil is wet.
6. Sensor embedded tool must not be buried too much deep under the soil.
7. For the internet facility, mobile data or wifi should be enabled.

2.1.8. Site adaption requirements

2.2. Product Functions

In the smart crop suitable system has several functions such as,

Predicting the best crop for a particular ground-
To achieve this, Use the sensor readings and compare them with relevant data sets.
We gather data sets to maintain best environment and fertility levels for main commercial crops such as tomato, chilies, papaya, banana, rubber, coconut and tea.

input	Soil samples got from the ground using zig zag method
output	Predicted best crop for the ground fertilizer level
process	Input data set is analysed and compare with the gathered dataset using an algorithm

Table 3: Product functions 01

Generating the future fertilizer plan for the selected crop.
Keep data set for main crops of what is the best fertilizer level to get the best results from growing the selected crop.

input	Crop selection
output	Future fertilizer plan for the selected crop to achieve best result
process	According to the selected crop, retrieve the best fertilizer level for the crop to gain best result

Table 4: Product functions 02

Pave the way for a better and easy way to have a successful cultivation.
According to the stage level of the crop growth, predict the best fertilizer level for the plant.
To achieve this keep store the relevant data set for main crops in according to the stage of the plant such as Transplanting, active tilling, panicle initiation, harvest.

input	Stage of the plant
output	Predicted fertilizer level according to the stage of the plant for best growth
process	According to the input stage compare with the gathered data set of fertilizer level of stage wise using algorithm to retrieve the best fertilizer level

Table 5: Product functions 03

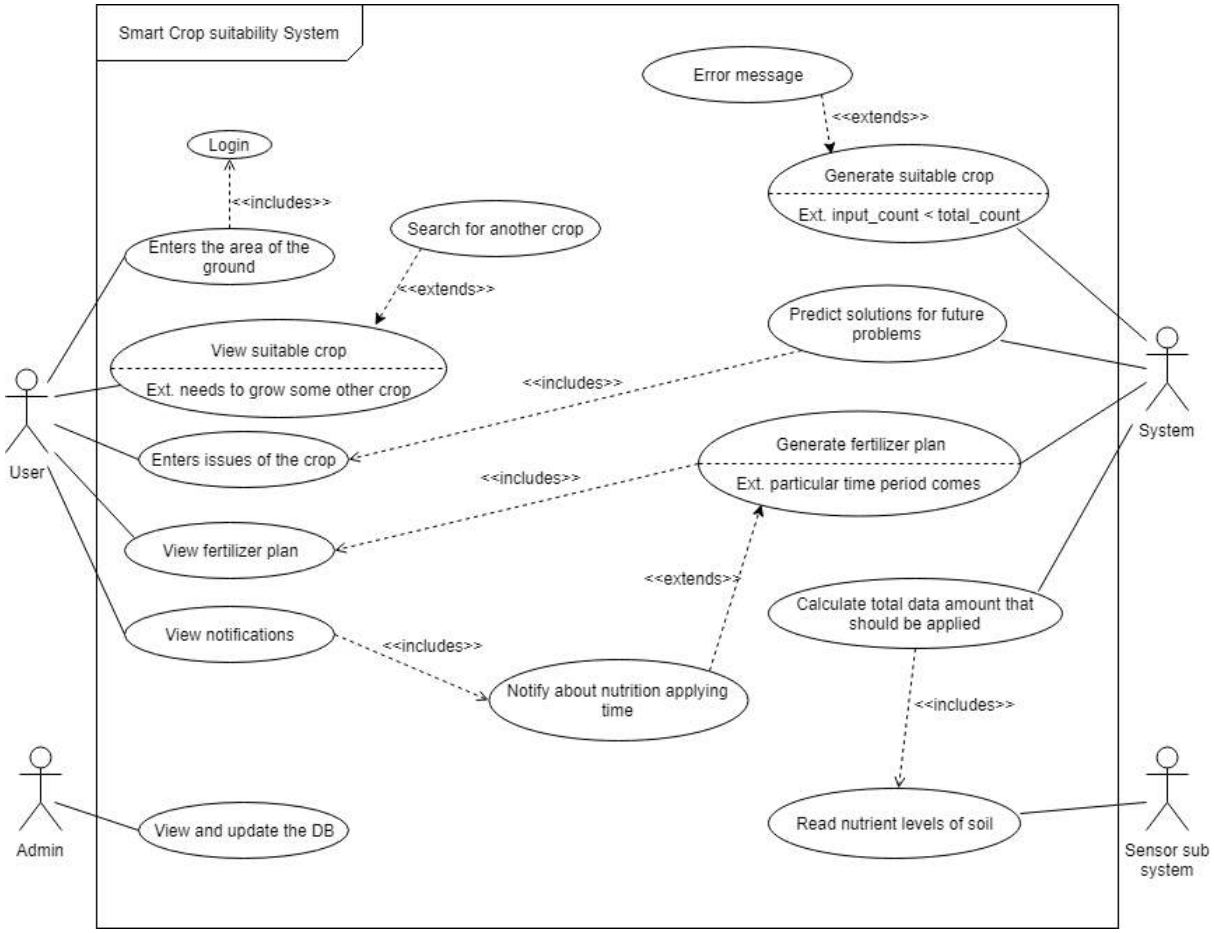

Figure 10: Use case diagram

Use Case Scenario

When designing the use cases, following use case scenarios can be used in the main function.

Use Case No	01
Use Case Name	Log in to the system.
Actors	User
Pre-Condition	The user should already be registered with the application
Main Success Scenario	1. Give username and the password in the login page 2. Click “Login” button to log in to the system. 3. The system prompts a message “Successfully login”
Post Conditions	The user has successfully logged in
Extensions	1a 1. If the password is not matched with the password for the username, the system prompts to re-enter the password. 1a 2. If the user enters incorrect passwords in three times, the system prompts for the email address.

Table 6: Use case scenario - Login to the system

Use Case No	02
Use Case Name	View Suitable crop fertilizer plan
Actors	User
Pre-Condition	The user should already be login to the system
Main Success Scenario	1. Open the mobile application 2. Login to the application 3. Click on the Suitable crop fertilizer plan icon or home page of the application 4. The system will show enter area space
Post Conditions	The user will be able to see the Suitable crop fertilizer plan for the entered ground

Table 7: Use case scenario - View suitable crop fertilizer plan

Use Case No	03
Use Case Name	Respond with Notification
Actors	User
Pre-Condition	The user should already be login to the system
Main Success Scenario	1. Open the mobile application 2. Login to the application 3. Pop up all remaining unread notifications 4. User clicks on the “ok” button 5. Pop up message will be disappeared.
Post Conditions	The system will be updated.

Table 8: Use case scenario - Respond with notification

Use Case No	04
Use Case Name	Enter issues
Actors	User
Pre-Condition	The user should already be login to the system
Main Success Scenario	1. Open the mobile application 2. Login to the application 3. User click on predict solutions for future problems. 4. System redirected to enter issues page and user enter issues
Post Conditions	The data will be saved into the database & user will see the predict solutions for user entered issues.

Table 9: Use case scenario - Enter issues

Use case ID	05
Use case Name	Calculate total data amount and analyze data set
Goal in Context	To Calculate total data amount and get the average fertilizer amount of the soil.
Primary Actor	system
Preconditions	1. There is an internet connection to the mobile phone. 2. There is a database connection to the user. 3. System connected to smart crop suitable device through WIFI connection
Main Success Scenarios	1. Get data from the device 2. Add data to relevant machine learning algorithm. 3. Calculate total data amount
Extensions	-

Table 10: Use case scenario - Calculate total data amount and analyse data set

Use case ID	06
Use case Name	Generate Fertilizer Plan
Goal in Context	To Generate Fertilizer Plan based on current fertilizer level on the ground
Primary Actor	System
Preconditions	1. There is an internet connection to the mobile phone. 2. There is a database connection to the user. 3. System connected to smart crop suitable device through WIFI connection
Main Success Scenarios	1. Include (View suitable crop fertilizer plan). 2. Replace the new crop fertilizer plan.
Extensions	Particular time come

Table 11: Use case scenario - Generate fertilizer plan

Use case ID	07
Use case Name	Predict Solutions for future problems
Goal in Context	To Predict Solutions for future problems faced by crop.
Primary Actor	System
Preconditions	1. There is an internet connection to the mobile phone. 2. There is a database connection to the user. 3. System connected to smart crop suitable device through WIFI connection
Main Success Scenarios	1. Include (Enter issues). 2. Update database with new issue list.
Extensions	-

Table 12: Use case scenario - predict solutions for future problems

Use case ID	08
Use case Name	Generate Suitable crops
Goal in Context	To Generate Suitable crop for the particular ground state
Primary Actor	System
Preconditions	1. There is an internet connection to the mobile phone. 2. There is a database connection to the user. 3. System connected to smart crop suitable device through WIFI connection
Main Success Scenarios	1. Include (View suitable crop suitable plan).
Extensions	input data count > total count

Table 13: Use case scenario - Generate suitable crops

Use Case No	09
Use Case Name	View and update crops
Actors	admin
Pre-Condition	The user should already be login to the system as admin
Main Success Scenario	1. Open the mobile application 2. Login to the application 3. User click on view or update crops. 4. Enter new crop suggestions or update exist one
Post Conditions	The data will be saved into the database.

Table 14: Use case scenario - View and update crops

2.3. User Characteristics

The “smart crop suitability system” product mainly depends on the mobile application and a tool with sensor hardware components. Because of that, the user must have the minimum knowledge to use a smartphone, use the sensor tool, basic knowledge of cultivation and fertilizers and English language skills. Because of this Product is based on cultivation, mainly target the farmers who have main idea about using smart devices.

2.4. Constraints

- A smartphone is required with enough battery life.
- For the communication between smart crop suitable system tool and the smartphone, required wifi connectivity enabled in a smartphone.
- For the communication between the smartphone and the database, required internet connectivity enabled in the smartphone.
- Android used, for the mobile application development,
- Cloud data base is used to store data to retrieve in relevant points.
- With the limited phone memory, the application should be able to run without any effect on the other operations and the processing speed.
- Raspberry pi3 model b+ board is required to use and some data is going to be stored in there.

2.5. Assumptions and dependencies

- The smart phone is switch on throughout the day as well as have the enough power of battery.
- The WIFI connectivity and the internet connectivity always enabled in the smart phone.
- Mostly the smart crop suitability system is used by people who have basic knowledge about fertilizers and cultivation.
- The information (ground details & details about fertilizer levels) which is provided by the user is correct
- Soil samples taken by zig zag method.
- Soil samples will get an average fertilizer level of whole ground.

2.6. Apportioning of requirements

For used this “smart crop suitability system”, first user must download “smart crop suitability system” mobile application from the google play store. After the install the application. After download the application user can provide details of user for the registration process and after registering process complete up user can log to the system using relevant credentials.

After the login and configuration, user mainly direct to the home page. In here user can visible some tips of cultivating. Additionally, user can select main functions of

the system (Recommend the best crop, Recommend the fertilizer usage, Suggest the future fertilizer plan).

User have to enter relevant data to particular functions such as stage level of crop, select the user defined crop.

3. Specific Requirements

3.1. External interface requirements

3.1.1. User interfaces

- Sign up – As the first step, user has to sign up with the mobile application.
- Create an account – If the user doesn't have an account, then this interface will give facility to create an account within simple steps.
- Login- using user credentials user can log in to the system.
- Home page-Through this interface user can view cultivating tips and redirect to the other main functions using buttons.
- Recommend the best crop interface-Through this interface user can view the best crop recommendation for the ground fertilizer level by analyzing the data set which get by the tool.
- Recommend the fertilizer usage interface-Through this interface user can view the recommended fertilizer by providing the selected crop.
- Suggest the future fertilizer plan interface-Through this interface user can view future plans and fertilizer levels according to the plant stage.
- Fertilizer level indicating alert-in this interface app showing the current fertilizer level of the soil by retrieve data set from the tool.
- User Details view interface-In this interface user can view details of the user account.

3.1.2. Hardware interfaces

As there are several objectives to achieve the final product feature, some hardware components are going to be used to satisfy those. Those hardware components are,

- Ph sensor -to identify ph level of the soil
- Temperature sensor -to identify the temperature of the soil
- Humidity sensor -to identify the water level of soil
- Electricity conductivity sensor-to measure ability to conduct electricity
- WIFI module- -for communication purpose between the mobile, smart crop suitability tool
- Smart phone - for the mobile application, suggest crops, show locations and user will be notified through the mobile. (Android version 6.0 or higher)
- Raspberry bi 3 model b+ –as the sensor hub

With all these hardware components and parameters, this proposed product will able to be more effective and accurate.

3.1.3. Software interfaces

Some software interfaces have to be used in this proposed system and they can be simply categorized with the relevant function and it will be able to understand clearly. Those are,

- Test soil sample and show the details of the soil by fertilizer wise: raspberry desktop application will be used to configure sensors.
- Visual Studio will be used to implement the mobile app.
- Google map API will be used for notifying the user about the soil state of the land according to the locations.
- Identify the user: To configure the database with the mobile application, developer need the “Firebase” web application

3.1.4. Communication interfaces

Mainly in this component the communication process will be happened through the WIFI connectivity. Therefore, raspberry pi and phone is connected always to retrieve data. As well for the communication between the application and database, and for crowdsourcing, internet facility should be enabled.

Moreover, the smart crop suitable system will get the current location using GPS module.

3.2. Architectural Design

3.2.1. High level Architectural Design

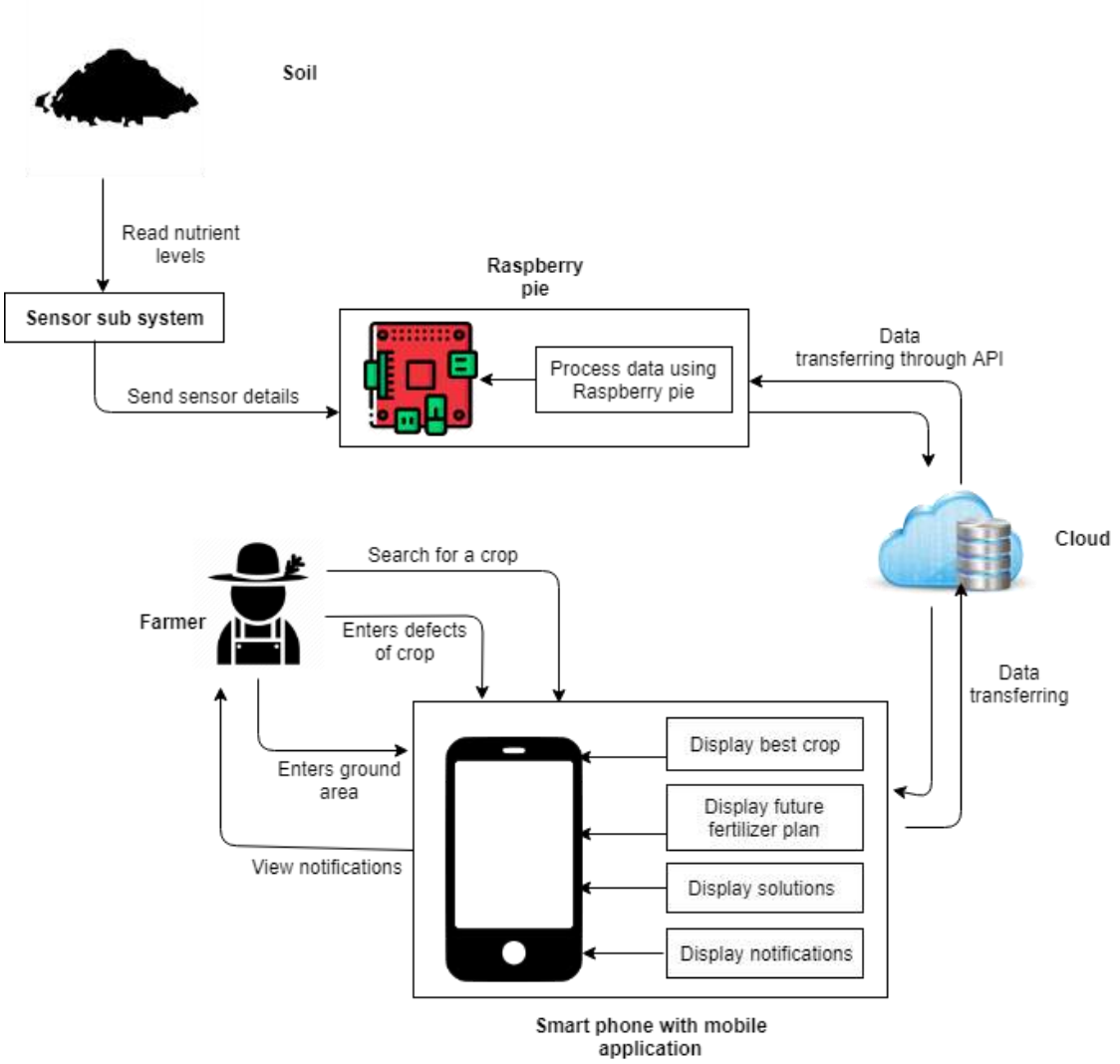

Figure 2: High level architectural design

3.2.2. Hardware and Software requirements with justification

As our proposed product will address to a common issue for the people who has an interest in cultivation, the final outcome should be more effective and accurate. Therefore, several software and hardware components have to be used for achieving this.

Hardware requirements

- pH sensor - Use to check the quality of the soil in a particular ground.
- EC sensor - Use to get the electrical conductivity of the soil.
- Humidity sensor - Use to identify the humidity of the air.
- Temperature sensor - Use to identify the temperature in the air.

Software Requirements

- Visual studio 2015 – Use to develop the mobile application using Xamarine.
- phpMyAdmin – To perform MYSQL database management.
- Cloud – To store sensor details and in-built data set to perform operations to generate the desired output.

3.2.3. Risk mitigation plan with alternative solution identification

Risk	Impact	Likelihood (%)	Mitigation Plan
pH Sensor is giving a faulty reading	3	5%	sensor is going to be used for quality checking
Humidity Sensor is giving a faulty reading	3	5%	sensor is going to be used for quality checking
temperature Sensor is giving a faulty reading	3	5%	sensor is going to be used for quality checking
EC Sensor is giving a faulty reading	3	5%	sensor is going to be used for quality checking
If there no network coverage in this place	1	50%	Save the data mobile phone and after available network saved in the database
Machine learning algorithm result is less accurate	3	30%	Train the algorithm using more data sets

Table 15: Risk mitigation plan

3.2.4. Cost benefit analysis for the proposed solution

Description	**Quantity**	**Price(Rs)**
Ph Sensor	1	350.00
Humidity sensor	1	350.00
Temperature Sensor	1	200.00
EC meter	1	450.00
HDMI to VGA adaptor	1	1225.00
Raspberry Pie 3 kit	1	7450.00
Screen for raspberry pi	1	1400.00
Memory card 16GB	1	1500.00
	Total	**12925.0**

Table 16: Cost benefit analysis

3.3. Performance requirements

- The sensor readings must be accurate and trustworthy.
- The system will operate with minimum 1GB RAM.

3.4. Design constraints

This product is focused on people without any age limitation, the user interfaces of the mobile application have to be simple, attractive as well as user-friendly. Therefore, people will be able to work with the proposed product easily and effectively with the use of these designed user interfaces.

3.5. Software system attributes

3.5.1. Reliability
3.5.2. Availability
3.5.3. Security
3.5.4. Maintainability

4. Supporting information

4.1. Appendices

[1]. S. Pudumalar, E. Ramanujam, R. H. Rajashree, C. Kavya, T. Kiruthika, and J. Nisha, "Crop recommendation system for precision agriculture," *2016 8th Int. Conf. Adv. Comput. ICoAC 2016*, pp. 32–36, 2017.
[2] S. Aswathy, S. Manimegalai, M. M. R. Fernando, and J. F. Vijay, "Smart Soil Testing," pp. 41–44, 2018.
[3]. S. Pudumalar, E. Ramanujam, R. H. Rajashree, C. Kavya, T. Kiruthika, and J. Nisha, "Crop recommendation system for precision agriculture," *2016 8th Int. Conf. Adv. Comput. ICoAC 2016*, pp. 32–36, 2017.